3.

Descriptive Ecology of La Cueva Chica, with Especial Reference to the Blind Fish, *Anoptichthys*.

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(Plates I–III; Text-figure 1).

Introduction.

A blind cave-dwelling characin was described from the state of San Luis Potosi, Mexico, by Hubbs & Innes (1936) under the name *Anoptichthys jordani*. The original material had been collected by Señor Salvador Coronado that year, and sent in a living condition to Mr. C. B. Jordan of Texas, who in turn transmitted the material to Dr. Hubbs. Since then the fish has become established in small aquaria as a novelty. Nothing was recorded concerning the habitat of the form other than that mentioned by Hubbs & Innes (1936) and Hubbs (1938).

The New York Aquarium undertook the organization of a small expedition to study the nature of the environment of this cave. This trip, in March, 1940, described by Bridges (1940), occupied fifteen days actually spent in the cave. The present report contains the observational data obtained and as much ecological data as the field work yielded. A fuller discussion of the biological implications must wait on further laboratory work, which was in progress at the New York Aquarium, and has lately been transferred to the Department of Animal Behavior at the American Museum of Natural History.

It had been the original plan to have this translated into Spanish, edited by Señor Coronado and published in Mexico as a joint contribution. Due to inability to maintain satisfactory contact with Coronado, and rather than have the finished manuscript lie for an indeterminate period, it was decided to delay publication no longer.

The author takes this opportunity to thank Señor Coronado for his able assistance in the field. His energy, indefatigable efforts and general help went far toward the successful prosecution of our field work and we are grateful to Señor Antonio G. Garcia, Jeffe del Departmento Technico de la Direccion de Pisca é Industrias Maritimas, for releasing him from his ordinary duties in our behalf.

This paper was to have preceded the following documents: Hobbs (1941), Breder & Gresser (1941a, 1941b and 1941c). This proved impractical because of the delay alluded to above. The present contribution records the basic field data of the expedition, including the climatic, geologic and faunistic conditions as encountered in La Cueva Chica.

Geology.

The accompanying map and vertical section of the cave, Text-figure 1, which has already appeared in Bridges (1940), gives a general idea of the cave. An inset gives the geographical location of the cave which is readily accessible from the concrete highway that runs from Laredo, Texas to Mexico City. All rock specimens have been examined by Dr. Horace E. Wood II and prove to be limestone formations of various types. The only exception to this is some litter on the floor of the cave which extends back to Pool No. 3. Presumably it actually goes further but is either covered with water or bat guano beyond that point. The litter itself consists of a wide variety of materials, mud, broken logs and water-worn stones and pebbles, some of which are conglomerates of reddish jade-like materials. These objects are carried in by means of rainy season torrents.

The entire region is honeycombed with sink-holes and caves of various sizes primarily formed by the solvent and eroding action of water. This water, heavily charged with calcium, has re-deposited materials to form stalactites, stalagmites and flow-stones, making typical cave structures. Apparently in La Cueva Chica both activities are going on simultaneously or alternately in different

places. The consequence is that there are many badly eroded structures, while a little distance from them are new ones in the early formative state. Broken chunks of rock clearly fall from the ceiling more or less regularly. Various types of stalactites, flow-stone and cup formations are all in evidence in the various photographs. There was also, in the higher places, a considerable amount of crystalline calcite, rhombic crystals, mostly blackish in color, and more or less amorphous masses with partly formed irregular crystals varying from yellow to tan.

Pool No. 1, well protected by rock walls and under a relatively low ceiling, was found to be covered with a fine dust, Plate I, Fig. 1. This was of a calcareous nature, checked by Dr. R. T. Cox spectographically, perhaps crystalized on the walls as the water receded and then powdered off on the surface of the water. It was not found in the damper portions further from the cave mouth.

The region is one of hot springs as well as normal and cooler surface water. One such hot spring, El Bañito, is only three miles from the cave under consideration. These springs are heavily charged with sulphur and evidence of the complete lack of connection with such places by La Cueva Chica is the absence of sulphurous odors and the abundant life it contains. All other places examined showed no evidence of blind fishes, nor did the local people know of any other than in La Cueva Chica. Near the river just east of Pujal a deep hole has a number of lateral fissures. In places where light enters, normal *Platypoecilus* and *Astyanax* may be found but the cave waters proper were barren. This so-called "well" is believed to intercommunicate with La Cueva Chica. Various springs in the immediate vicinity show similar conditions, as does El Nilo, a cave from the mouth of which water flows, reversing sequences at La Cueva Chica.

Because of certain geological features of the general region and the interest in the possible effects on evolution of radioactive materials, tests were conducted on the presence of such emanations. Dr. M. D. Whittaker of the Department of Physics of New York University kindly undertook to make such tests on a series of water samples from each pool including evaporated concentrates. His findings were completely negative. Since, if radioactive material were present, they would surely appear in the ground waters, it is considered established that evolutionary activity in this cave proceeds without any such acceleration.

For a general discussion of the geology of the region, see Schuchert (1935) and Muir (1936). The accompanying photographs show clearly the general nature of the formations. Still other photographs of the cave are given in Bridges (1940) and Dunton (1940).

Water.

The chemical nature of the water of La Cueva Chica is shown in Table I. The analyses have been made by the Laboratory of the New York City Department of Water Supply through the courtesy of Mr. Herman Forster. These analyses show that the cave waters are high in nitrogen as compared with the river samples. The springs, as would be expected, are intermediate.

The chlorides, while variable, show no distinct trend from one type of water to another.

The hardness of the underground waters is clearly less than that of the surface streams, which in part at least probably accounts for the preference of the local people to caves for their water supply. On the other hand, the alkalinity tends to be higher in the caves than outside.

Phosphates are practically absent, being reported as "considerably less than .05 ppm PO_4."

Sulphates, on the other hand, are high in the surface waters and in one of the hot springs. They are relatively low in the cave waters.

The water apparently feeds into Pool No. 1 or 2 through subterranean springs. The former is probably connected with the latter as is indicated in the map, Text-fig. 1. Pool No. 2 spills over into a running brook which widens in the area of the series of cups from which it runs into Pool No. 3. It drops into this over a nearly vertical plunge of about 25 feet. This flow continues on until the major bat roost is reached. Here there is a small waterfall from an overhanging shelf and further on another, in two streams down a mud slope to Pool No. 4. The water draining into Pool No. 4 is clearly of considerably greater volume than that leaving Pool No. 2. Consequently, it is to be interpreted that there are a considerable number of tributary additions along this length of the gallery. In fact, in many places there are to be seen wet and dripping places on the walls, showing the influx of additional water.

The water in all places is crystal clear, even in the far recesses of the cave where everything is floored with and the water surface covered by bat guano. The temperatures and pH readings are given in Table I. These both are remarkably uniform and no significant temperature differential could be noted between surface and bottom in depths up to twenty feet. An exception to this must be made in several readings of temperature in the small basins above Pool

TABLE I.

Temperatures, Humidities and Water Analyses.

	LA CUEVA CHICA												OTHER LOCALITIES					
	POOLS						Mouth	Limit of	Pool	Small Basins Above Pool No. 3			La Poza de la Virgin	Rio Tampaon	Springs Between Pujal and Valles		El Nilo	El Banito[2]
	No. 1	No. 2	No. 2	No. 3	Outside of Cave		of Cave	Daylight	No. 2									
Date (March 1940)	11	11	14	14	14	19	19	19	19	18	18	18	20	20	21	21	23	25
Air °C.	—	—	22.8	—	20.6	25.3	25.6	22.2	23.3	26.0	26.0	26.0	32.0	27.5	33.3	33.3	25.6	—
Rel. Humidity %	—	—	84	—	—	67	57	98	93	—	—	—	—	—	—	—	—	—
Water °C.	26.1-27.	26.1-27.2	26.7[1]	—	—	—	—	—	—	23.5	24.0	25.0	26.5	25.0	27.8	29.4	22.2	32.8
pH	8.0	8.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8.0	7.9

Laboratory Analyses.

	CAVE WATERS			COOL SPRINGS			HOT SPRINGS[3]		RIVERS	
	La Cueva Chica Pool No. 2	La Cueva Chica Pool No. 3	El Nilo	Near Pujal	Between Pujal and Valles	La Poza de la Virgin	El Banito	Taninul	Rio Tampaon	Rio Taninul
Date (March 1940)	14	19	23	15	21	20	25	29	20	29
Albuminoid ammonia (p.p.m. Nitrogen)	.300	.260	.260	.180	.200	.480	.180	.260	.120	.160
Free ammonia (p.p.m. Nitrogen)	.480	.280	.160	.260	.480	.380	.340	.600	.200	.220
Nitrate (p.p.m. Nitrogen)	1.00	2.00	5.50	0.30	0.10	1.50	0.10	0.10	0.10	0.30
Chlorine (p.p.m.)	4.0	8.0	5.0	9.0	8.0	20.0	7.0	188.0	11.0	4.0
Hardness (p.p.m. Calcium Carbonate)	310	230	290	300	360	110	540	360	790	610
Alkalinity (p.p.m. Calcium Carbonate)	282	218	234	282	310	76	286	318	134	246
PO_4 (p.p.m.)[3]	nil.	nil.	nil.	nil.	nil.	nil.	nil.	nil.	nil.	nil.
SO_4 (p.p.m.)	16	24	6.0	19	77	1.4	267	47	600	376

[1] At surface and at bottom (12′).
[2] Sulphur water.
[3] Considerably less than .05 p.p.m. PO_4.

No. 3. Here readings of 23.5, 24.0 and 25.0 were recorded. This seemed to be associated entirely with the speed of flow through a given cup, those receiving a good flow being substantially the temperature of the large pools, while those that were relatively stagnant varied, generally on the high side, presumably increasing in temperature because of the generally warmer cave atmosphere.

The entire temperature situation in this cave is apparently influenced by the proximity of the underlying magma. We are assured by Dr. H. E. Wood II that such temperatures could not be maintained in such a cavern on a basis of surface air and water temperatures alone.

During the rainy season it is impossible to enter the cave, according to local statements. When seen by us a completely dessicated stream bed led into the mouth of the cave. In addition to local statements there was much evidence that during the rainy season this stream becomes a roaring torrent, almost surely completely closing the cave mouth. The internal evidence of the cave supported this, and it would seem that the place fills with water with the possible exception of the high-vaulted chambers which may hold pockets of air at all times. Mud carried to high cavities in the wall gave evidence of this. A considerable formation of flow-stone steps is reached before Pool No. 1 is found, and were perfectly dry at the time of our visit.

Probably early in the season most of the action of the water is corrosive and attritional, while later with the water moving slowly with both solution and deposition going on, there is a tendency to build up more deposits of limestone, which process goes on throughout the dry season wherever water remains.

Locally the water is considered thoroughly potable and is much used by a nearby Indian village, inhabitants of which draw their water from Pools No. 1 and 2.

Cave Climate.

The climate of La Cueva Chica at the time of our visit was fairly static, but probably this cave varies considerably throughout the year in regard to temperature and humidity, at least much more so than most caves that have been reported on, partly because of its small size.

Since water enters the cave in great quantities for part of the year, it undoubtedly influences the temperature to a considerable extent, very likely tending to reduce it, since swollen, rainy-season streams are generally much cooler than other surface waters.

The ventilation of this cave is extremely limited. The only openings to the outside that we could find were the entrance we used and a small crevice opening about two hundred feet away. This latter was detected only by reason of some smoke from photographic flares, used for the taking of motion pictures, finding its way out this small opening too narrow to pass a man. The behavior of smoke from these flares and the long time it hung in the chambers precluded the existence of any hidden crevice of importance. Also, the behavior of the bat colony indicated that they used the one major entrance only.

Although the air was oppressive and heavy, it was not unpleasant to smell until the area of the major bat roost was entered. Here it had the acrid, gagging characteristics generally associated with a sizeable bat colony.

Apparently the only change of air is that induced by weather changes, which "pump" air in or out, depending on the behavior of the barometric pressure. Added to this would be whatever dissolved gases invade or evade through the water surface to accumulate or be carried along to greater depths by the water flow. The daily flight of bats in and out no doubt also contributes to the agitation of the air, preventing any stratification.

Up to the first pool the direct effects of daily weather changes could be detected. That is, on dry days the walls would show condensed moisture where the damp air of the cave tended to cool when it made contact with the outer dry air. Here at such times the atmosphere of the entrance was refreshing, but beyond such a point, varying from day to day, it was consistently oppressive.

Data on temperature and humidity are given in Table I.

Terrestrial Organisms.

The only moderately large terrestrial animals that apparently dwell regularly in La Cueva Chica are the bats. These are exceedingly numerous, and while it was not the purpose of the expedition to study the bats, they were sufficiently conspicuous to warrant some remarks. When Dr. Myron Gordon entered the cave in 1939 as far as Pool No. 2, he found a good sized colony over that body of water. On our visit we did not encounter more than a few small groups of bats until the region marked on the map "minor bat colony" was reached. From here on bats were numerous, concentrated into two colonies, the second of which was immense.

The few specimens collected were kindly identified by Dr. J. E. Hill, of the American Museum of Natural History, as: *Artibeus jamaicensis* Leach, *Natalus mexicanus* Miller and *Mormoops megalophylla senicula* Rehn. Due to the inrush of water in the

ainy season these bats almost surely must acate the cave for part of the year. *Micronycteris megalotis mexicanus* Miller vas taken in El Nilo.

Mr. Marshall Bishop reported seeing some bats scamper high up the walls in true vampirine fashion. This, coupled with local accounts of vampire attacks on farm animals, sounded convincing, and the finding of droppings in El Nilo that looked very typical of vampire droppings, leads us to believe that they are actually dwelling in this region.

Aside from that of human beings, there was no other evidence of mammalian activity within the cave. Birds, reptiles and amphibians seemed to be completely absent.

Arthropods in the form of insects and arachnids were ubiquitous. A representative collection was made by Mr. Bridges and has been deposited in the American Museum of Natural History. They will form the basis of a separate report by Dr. W. J. Gertsch. Probably the most conspicuous insects were small flies which flew about our lights in large numbers. These flies were kindly identified by Dr. C. H. Curran, of the American Museum of Natural History, as *Pholeomyia indecora* Lowe (Milichiidae) and some *Psychoda* sp. (Psychodaidae). The former was the predominant form. The most evident arachnids were large whip-scorpions which clung openly to the walls.

The bat guano contained great quantities of a macroscopic free-living nematode. When this material is finally studied it will probably be found to contain a fauna of some variety. This material is now in the hands of Dr. R. F. Nigrelli.

Aquatic Organisms.

The invertebrate aquatic organisms consisted of microscopic forms and two macroscopic forms. One, a crayfish, *Macrobrachium jamaicensis* (Herbst), which was lighter in color than those outside but with functional vision, is not to be considered as a cave form proper. Another, and smaller form, has been described as a new subspecies by Dr. H. H. Hobbs, Jr., under the name *Cambarus blandingii cuevachicae*, (Hobbs 1941). This lack of optical differentiation is equally true of the microfauna which is being studied by Dr. Nigrelli.

The only aquatic vertebrate encountered was the fish that the expedition set out to study. These fish had twice before been collected. Originally they were taken in 1936, as discussed in the introduction. Gordon and Coronado in 1939 made a hurried visit to the cave and took a second collection. In the first visit specimens were taken from Pools 1 and 2, while on the second they could be found only in Pool 2. As neither party was equipped to go further than Pool 2, it remained for the present and third to examine the fish fauna to the workable end of the cave.

The most striking feature of this faunal unit was the discovery that these blind fish were not a uniform group. The fish previously collected were all blind and their offspring likewise grew up to be sightless creatures. Mr. Albert Greenberg of Tampa, Florida, has been especially successful in breeding this fish in captivity and obtained uniform material to the fifth generation. Shortly after the return of the expedition, a visit to his establishment showed that he had thousands of specimens of various ages, and he had noted that although he had reared them through five generations in light, all were completely blind.

It was quickly found in the cave that the fish ranged all the way from eyeless, pale creatures to fish that could not be distinguished from the normal river *Astyanax mexicanus* (Filippi).

The introduction of a light into the cave apparently causes those individuals endowed with eyes sufficiently perfect to recognize a light beam to retreat hastily, while the truly blind individuals seemed to give no attention to the strongest beam of a flashlight (See Breder & Gresser, 1941a, 1941b and 1941c). It was only after we had become thoroughly familiar with the cave and had baited the fish to given spots that we obtained the eyed and partially eyed forms.

Further, we found that there was a distinct gradient in that the further we went into the cave the more numerous became the fully eyed forms, and those fish not at all distinguishable from the normal river fish were only obtained beyond the large falls at Pool 3. Table II gives a measure of this gradient based on the arbitrary division of the fishes in blind, sunken eyed, covered and uncovered, and "normal-eyed," as based on our preserved collections. These rather arbitrary categories may be described as follows:

Blind—Eye socket covered with tissue level with the cheek, no evident eye structure.

Sunken eye—Some evident eye structure, but sunken below rim of orbit.

- *Covered*—Evident sunken eye covered with tissue.
- *Uncovered*—Evident sunken eye exposed as in a pit.

"Normal"—Eye convex and appearing as in a river fish, irrespective of its size, which was frequently very small.

Pigmentation followed a similar course although not fully correlated with eye structure. The pigmentation has been also arbitrarily divided, the five categories of which

TABLE II.

Eye Condition and Pigmentation of Cave Characins.

Eye Condition

Expressed in % of catch.
Based on 119 specimens.

Location[1]	Blind	Sunken Eye Covered	Sunken Eye Uncovered	"Normal" Eye
Sta. 1	85	6	—	9
Sta. 2	16[2]	8	45	31
Sta. 3	—	9	9	82

Pigmentation

Location	None	Little	Moderate	Considerable	Full
Sta. 1	90	2	6	2	—
Sta. 2	34[2]	34	5	8	19
Sta. 3	3	29	32	24	12

[1] Sta. 1 indicates Pool II on map; Sta. 2, Pool III and Sta. 3, Pool IV.
[2] Two specimens in this group blind on one side only.

are given in Table II. The extent of correlation of these two features associated with cave life are indicated in Table IV.

The sizes of the eyes of those fish with "normal" eyes are given in Table III, compared with river fish. Because of the variation in relative eye size with absolute size in fishes, this table has been broken into three size groups for purposes of comparison. From this treatment it is clear that the cave fishes extend from normal eye size to very small as compared with the river fish. Actually, the smaller eyed fishes taken in the river may represent a true genetic contaminant issuing from the cave or a general constitutional and initial eye variation in this group.

Since the connection with the river is from the far end of the cave there may be a more or less continual interchange between the river and cave fauna.

The cave ends, as far as human entry is concerned, in an eliptical chamber, the form of which is well indicated in the map and section together with the presumed underground exit of the flowing water. Here the Rio Tampaon is about half a mile distant.

A study of this variation in the eyes and pigmentation of these fishes must be reserved until an extended laboratory effort is made to obtain at least a basic understanding of the genetic foundation of this population. Because of the bearing on laboratory work the data of Tables II and IV have been used by Breder & Gresser (1941a).

During our visit to the cave, the fish were clearly in their reproductive season. Large females turgid with eggs were common as were small specimens that could not have been more than a month old. Mr. Greenberg found that in captivity the addition of some cold water to an aquarium would induce spawning, which led him to suppose that the rainy season might be the reproductive period. These two items taken together might be used to argue that spawning occurs throughout the year, the peak perhaps being reached when the rains come. Against this view would be the mechanical circumstances accompanying the torrential waters passing through the cave during that period, which would hardly seem friendly to spawning, especially of the type employed by these blind fish.

The sexes of the fish, together with their sizes, are given in Table V.

An attempt to examine the scales of these fish led to the surprising finding that replacement scales were the rule rather than the reverse. In fact, only thirteen of the twenty fish large enough to show markings were useful in this connection, as is indicated in Table V. Whether this is to be construed as evidence that due to swimming in the dark these fish continually knock scales off themselves or whether they take a serious battering when the torrents of the rainy season come, can only be speculated upon at this time. Although these fish under certain conditions will ram into objects, Breder & Gresser (1941a and 1941c),

TABLE III.

Eye Size of Cave and Surface Characins.

Expressed as % of standard length.
Based on 69 specimens with "normal" measureable eyes.

Size Range S.L. in mm.	Cave Specimens Maximum	Cave Specimens Mean	Cave Specimens Minimum	Surface Specimens Maximum	Surface Specimens Mean	Surface Specimens Minimum
0 – 30	11	9	7	12	11	10
31 – 60	10	7	5	10	8	6
61 – 90	8	6	5	8	8	8

TABLE IV.

Association of Eye Condition and Extent of Pigmentation.

Expressed in % of extent of pigmentation.
Based on 119 specimens.

Eye Condition	Extent of Pigmentation in Per Cent: None	Little	Moderate	Considerable	Full
lind	98[1]	—	2	—	—
unken Eye (covered)	56	33	11	—	—
unken Eye (uncovered)	—	62	15	15	8
Normal"	2	23	28	23	24

[1] Two specimens in this group blind on one side only.

here is no observation noting that they dis-odged scales by such accidents.

It would be unwarranted to attempt to efine the nature of the markings on the cales as to whether they are annual or therwise. While they seem to occur in a easonable sequence with size, we have no way of equating this with time.

Although we know nothing of the various effects of their underground environment on the circulae of the scales, it must not be supposed that it is markedly uniform, for there is a clear annual cycle in the wet and dry season rhythm of this region. The fish are surely subjected to an annual change in temperature, quantity of water, rate of flow, food and perhaps in the chemical nature of the water itself.

The food problem, as already suggested by the presence of other than cave creatures, is simple in this cave. The great abundance of food objects leading directly to the outside renders the problem of primary diet quite simple. Organisms all the way from *Cyclops* and dipterous insects to the entire carcasses of bats are available to these fishes. Their stomach contents were found to consist of bat droppings and parts of other and smaller cave characins and their eggs. This would suggest that the only regular input of energy into the population for large parts of the year is bat dung. Their ability to thrive and reproduce on the ordinary foods supplied to small aquarium fishes also suggests the lack of any peculiar specialization in dietary requirements.

DISCUSSION.

The primary items of a cave fauna such as the present certainly center about the manner of establishment of a population of blind fishes and the nature of the association of lack of light and congenital blindness. Superficially simple-looking, critical examination of the possible development of such a condition presents some distinctly puzzling phases.

The finding of a long series of intermediates between the blind fish and the normal eyed river fish, which in itself is unique among cave fishes, gives hope that this material should prove of value in any attempt to understand this general association of blindness and darkness. Such a study, however, involves much further work.

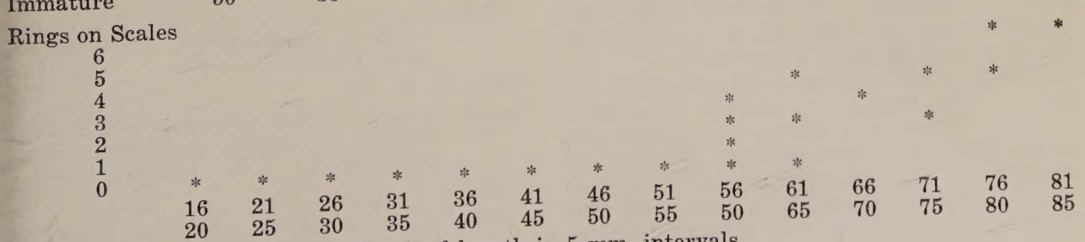
As the situation stands, the facts in hand are subject to various interpretations. It might be assumed that these fishes in their normal river environment carry the genetic factors for an eye defect. Dr. C. L. Hubbs informs me that large series of Mexican *Astyanax* which he has examined show a surprisingly large amount of individual variation in eye diameter. Blind larval fishes

TABLE V.

Size, Sex and Growth of Cave Characins.

Based on 119 specimens.

Sex	Standard Length in mm.: Maximum	Mode	Minimum
Female	83	45 – 50	40
Male	62	50 – 55	38
Immature	50	35 – 40	16



Of the 20 fish above 55 mm. only 13 had other than replacement scales.

in the open river could hardly be expected to survive. However, with these fishes finding the way into cave waters, the eyed offspring presumably would have no advantage over the eyeless, resulting in the survival of some of each.

Following this thought along, two possible conditions suggest themselves.

It could be that such an entry was made some time ago and the resultant population as found is cut off from the river fauna and the eyed fish go on living in the absence of any detriment to having eyes, even if they cannot be used.

An alternative interpretation would be that there is a continual interchange of fishes between the cave and the river. It is not surprising that blind fish are not to be found in the river, for they clearly have strong disadvantages in such an environment, principally their blindness and conspicuous light hue. The contrary would not hold, and there may a more or less continual penetration of the cave waters by normal river fish. If this latter view is correct, it would suggest that the development of such a population of blind fish took a much longer time than would the first alternative, because of the slowness of the spread of a character that is evidently recessive in a continually diluting population. The finding of a progressive series of eyed fishes as one moves toward the river encourages such a view.

A quite different interpretation would be to assume that at some distant time a group of fish became entrained in this cave in a state of complete isolation and became blind by whatever mechanism operates under such conditions. Then a further assumption would be made that this population of thoroughly blind fish again came in contact with the normal river fish from which they were originally derived. The resultant stock as found would then be the hybrid mixture of these two groups. The increasingly higher number of eyed fishes as one nears the river would be compatible with this view.

Other views concerning the possible direct effect of environment on vision and pigmentation find little support in the present material. There are eyed and intermediates living in the cave successfully with the eyeless for an unknown number of generations. Five generations of the entirely blind stock reared in brilliant light show no suggestion of returning vision or pigmentation.

Experimental studies are here called for and in the words of Gresser & Breder (1940), "Until at least some of these are undertaken, it would seem to be pointless to attempt further speculation." Progress in this direction has already been made and is reported in Breder & Gresser (1941a, 1941b and 1941c).

Summary.

1. La Cueva Chica is able to support a population of temperature limited characins by virtue of nearby thermal waters which prevent the subterranean waters from falling below a relatively high value.

2. The cave characins are supported by a large variety of food items which trace directly or indirectly to the outside by way of bat droppings.

3. The cave characins (*Anoptichthys jordani*) show complete intergradation with the river characins (*Astyanax mexicanus*) through a long series of individuals with intermediate eyes and pigmentation and surely represent a single population. There is a pronounced gradient in these features from one end of the cave to the other.

4. Other animal organisms found living in the cave, bats, crustaceans, insects, spiders and related forms and a considerable microfauna, are not modified in any way comparable to that of the fishes and are not confined exclusively to a cave habitat.

5. The cave itself, small in extent, so far as human entry is concerned, except for its high temperature is typical of limestone formations and shows no other exceptional features.

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EXPLANATION OF THE PLATES.

Plate I.

Fig. 1. Calcareous scum on the surface of Pool No. 1. Photo by E. B. Gresser.

Fig. 2. Blind fish as found in Pool No. 2. Here the individuals are nearly all of the fully blind type. This is the place from which the original collection was made, representing at once the exact type locality as well as the source of the parent stock of this form now to be obtained from dealers. Photo by S. C. Dunton.

Fig. 3. Cup-like basins below Pool No. 2. Photo by S. C. Dunton.

Plate II.

Fig. 4. Pool No. 4, showing the low arch across its middle. The material floating on the water is caked bat guano. Photo by S. C. Dunton.

Plate III.

Fig. 5. Cave fish in various stages of eye degeneration. Reading from the top down: Fully blind and pigmentless type; Somewhat pigmented with a minature eye; "normal" fish from cave; "normal" fish from the Rio Tampaon. Photo by S. C. Dunton.

FIG. 1.

FIG. 2.

DESCRIPTIVE ECOLOGY OF LA CUEVA CHICA, WITH ESPECIAL REFERENCE TO THE BLIND FISH, *ANOPTICHTHYS*.

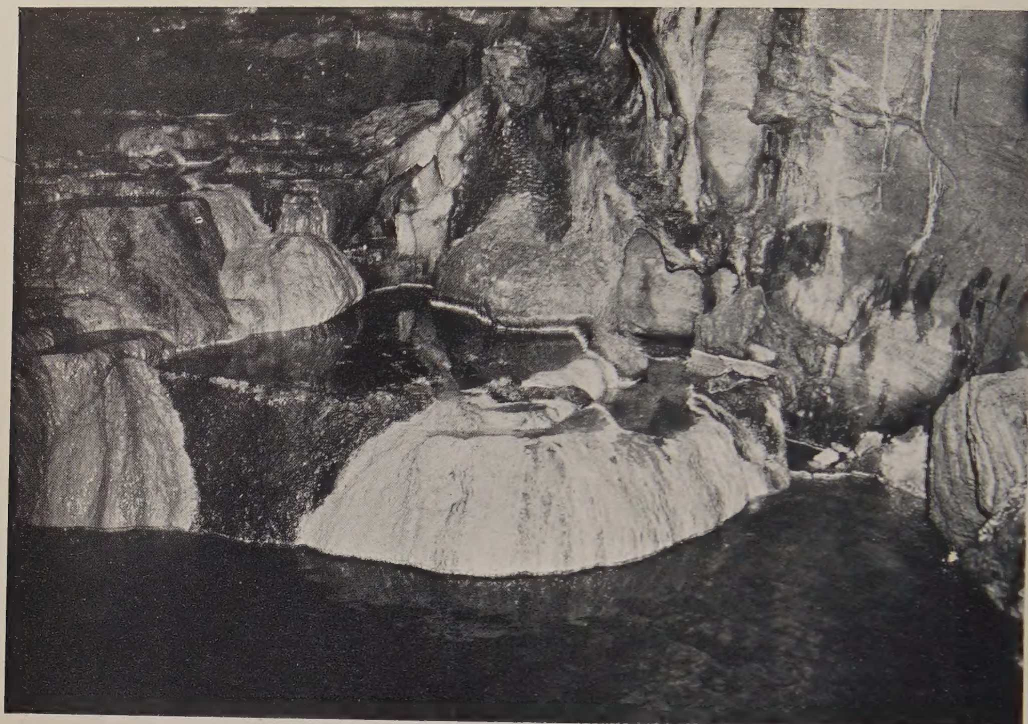

FIG. 3.

FIG. 4.

DESCRIPTIVE ECOLOGY OF LA CUEVA CHICA, WITH ESPECIAL REFERENCE TO THE BLIND FISH, *ANOPTICHTHYS*.

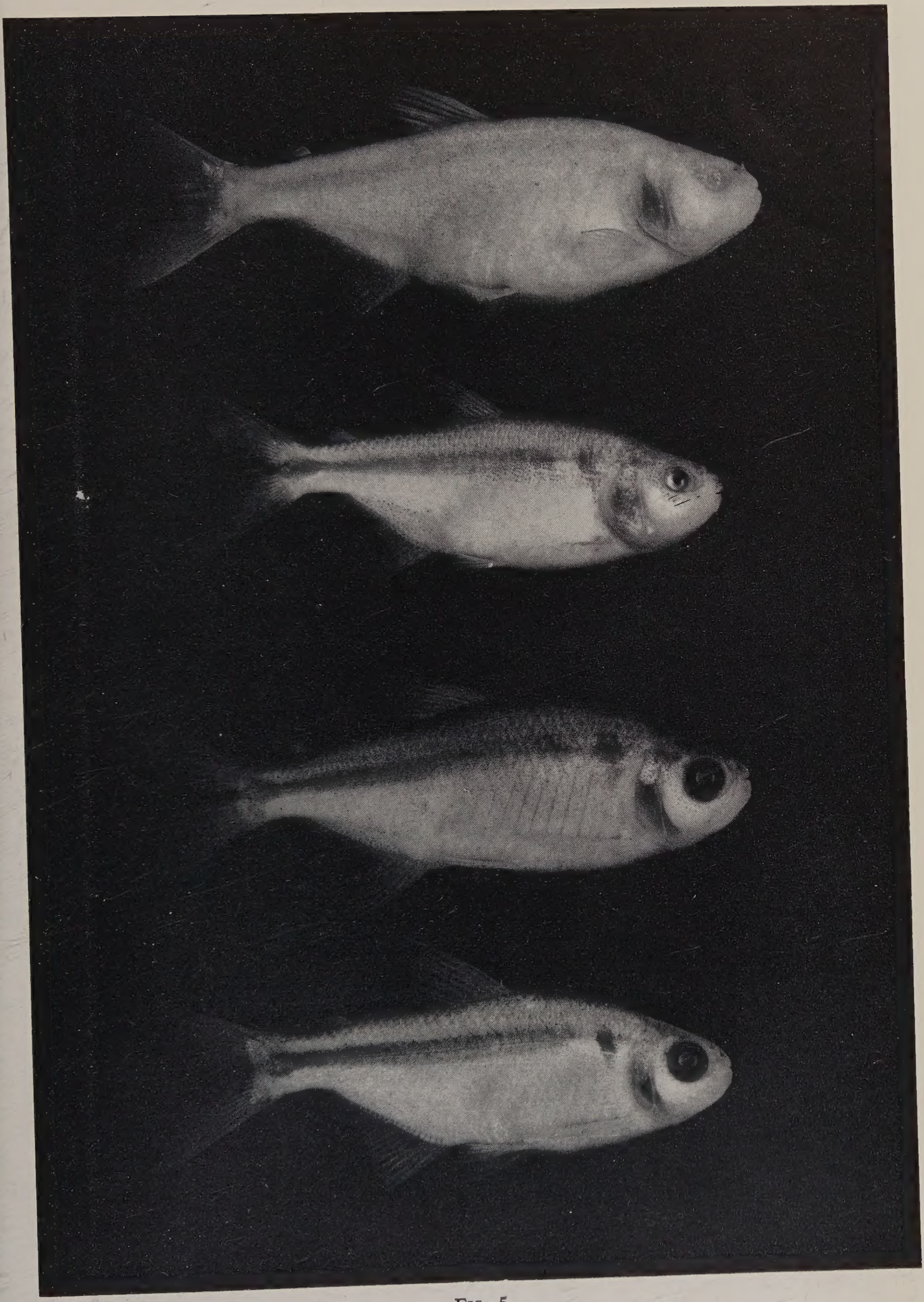

FIG. 5.

DESCRIPTIVE ECOLOGY OF LA CUEVA CHICA, WITH ESPECIAL REFERENCE TO THE BLIND FISH, *ANOPTICHTHYS*.